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BUREAU OF ... INDUSTRY

CIRCULAR No. 153 FEBRUARY, 1931
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

METHODS OF SEED PRODUCTION FROM SUGAR BEETS OVERWINTERED IN THE FIELD[1]

By JOHN C. OVERPECK, *Professor of Agronomy, New Mexico College of Agriculture and Mechanic Arts,* and *Agent, Office of Sugar Plants, Bureau of Plant Industry,* and HARRY A. ELCOCK, *Assistant Pathologist, Office of Sugar Plants, Bureau of Plant Industry*

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INTRODUCTION

Seed standards are very exacting in the highly specialized sugar-beet industry. The European sugar producers have long since realized that the success of the intensive cultural operations involved in the crop and profitable return from the millions of invested capital are dependent upon the quality of the seed used. The American farmers and beet-sugar manufacturers are becoming more and more aware of the significance of seed quality, as witnessed by their insistence on receiving the best available seed supply. For the 5-year period ended with 1929 the annual imports of sugar-beet seed from Europe averaged 12,500,000 pounds to supply the normal seed requirements of the 700,000 acres ordinarily devoted to commercial production of sugar beets in the United States. The aggregate amount expended by the farmers for sugar-beet seed, based on the average price of 15 cents a pound, is upwards of $2,000,000 a year, of which three-fourths is paid to the foreign seed producer and distributor and the balance for transportation and handling charges.

It is easy to understand the present situation in which the American beet-sugar industry finds itself with respect to its great dependence on foreign sources for its sugar-beet seed supplies. During the last 20 years successful production of sugar-beet seed has been carried on in the United States by several of the large com-

[1] The work on which this publication is based was done in cooperation between the Bureau of Plant Industry, U. S. Department of Agriculture, and the New Mexico College of Agriculture and Mechanic Arts.

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panies. However, costs of production have been large and maintenance of quality has been difficult. Since the quality of the purchasable seed has been satisfactory in the main, and the price lower than the net cost of home production, taking into account costs entailed in breeding the seed stocks necessary to maintain quality, the American industry has for the most part preferred to purchase its seed supply from abroad.

This policy led to a disastrous situation at the time of the World War, when the supply of foreign seed was no longer obtainable, on account of blockade and ship shortage, and the results of hasty attempts to create a seed-growing industry in the United States were far from satisfactory. At the present time several beet-sugar companies produce a small portion of their seed supply in order to maintain an organization capable of meeting emergencies. It is also a common practice among some sugar companies to carry at least one year's seed supply in their warehouses.

In this circular, the production of sugar-beet seed is considered for an area in the southwestern United States where profitable crops are rather restricted in number because of climate, geographical location with respect to markets, and other factors. The volume of the business is such that this home production of sugar-beet seed would be an important addition to the income of the seed grower. From this standpoint, therefore, the development of an American sugar-beet seed industry should be encouraged.

The most important point involved in the domestic production of sugar-beet seed for the American industry, however, comes from the intimate connection of this program with the program for the control of serious plant diseases, and the development of strains of commercial beets especially adapted to specific areas in the United States. It is a known fact that the sugar-beet industry is in a precarious condition in many areas, because of certain epidemic diseases of the beet plant, and also because of the serious effects of climatic factors in certain seasons upon production. An important consideration which has contributed to the persistence of these conditions year after year is that beet breeding and selection as now carried on abroad do not furnish the means for development of strains of beets bred or selected to cope with the conditions under which most of the commercial sugar beets are grown in the United States. The absence of the particular diseases and the marked differences in climatic factors in the foreign areas where beet breeding is carried on gave rise to the existing situation. To illustrate with a specific case, it is essential that disease-resistant strains be developed for the curly-top disease of sugar beets, and this can be done only in those areas where the disease is prevalent, thus permitting the testing and selection of resistant individuals. No progress has yet been made by foreign seed breeders in this regard, since curly top does not occur in Europe. For an advance along this line of breeding, experimental work must be carried on in the United States.

Aside from the disease factor, the reaction of sugar-beet strains to climatic and soil conditions determines the yield in tonnage and sugar production; hence it would obviously be highly desirable if strains adapted to specific areas could be produced at home.

With the development of strains of particular merit for one locality or another by beet breeders, it is logical to suppose that the same situation which holds true with other crops will also prevail in the case of sugar beets. The interested purchaser will be vitally concerned in securing the seed stocks best suited to his conditions; also he will desire that the seed production be carried on near at hand so that he can be acquainted with the development, testing, and increase of the adapted material.

For these reasons, experiments with the growing of seed in the United States under conditions that will most nearly meet the commercial demands are of great importance.

SUGAR-BEET SEED GROWING IN THE UNITED STATES

According to Palmer,[2] the first carefully planned experiment in the United States in sugar-beet seed growing was made at Schuyler, Nebr., in 1891, by the United States Department of Agriculture under the direction of the late Harvey W. Wiley. Since that time it has been shown that seed can be produced in many of the States—Washington, California, Idaho, Colorado, Montana, Utah, Michigan, Kansas, and others.

A review of the possibilities of seed growing in the United States under methods that approximate those used in European countries was given by Townsend [3] in an article published in 1916, and in one by Tracy [4] in 1920.

Owing to various factors, chiefly the cost of domestic seed production, in which the hand labor involved was the chief item of expense, the sugar-beet seed industry has not developed in the United States. No distinctly American strains of sugar beets have been produced for commercial seed production, with the exception of limited quantities of material grown by certain western companies. At present, of the total amount of seed used in this country, less than 1 per cent is now produced in the United States.

A contribution which may have significant bearing on the American seed situation was made when the senior writer,[5] in cooperative experiments with the United States Department of Agriculture and the New Mexico Agricultural Experiment Station, showed that by taking advantage of the mild winter conditions of the southwestern part of the United States fall-planted beets could be overwintered in the field, and that satisfactory seed crops were produced from such field plantings. This method eliminated the labor of lifting, siloing, and replanting the stecklings or mother beets. Likewise, in the matter of seed increase, a great lowering in cost of production was made possible by reducing to an almost negligible amount the hand-labor expense, which formerly was the limiting factor.

The senior writer, as a result of test planting in 1925–26, showed that plantings made from August 1 to September 15 gave yields of seed ranging from approximately 1,000 to 2,000 pounds per acre.

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[2] PALMER, T. G. SINGLE-GERM BEET BALLS AND OTHER SUGGESTIONS FOR IMPROVING SUGAR-BEET CULTURE. U. S. Dept. Agr. Rpt. 74 : 141–152. 1903.

[3] TOWNSEND, C. O. THE PRESENT STATUS OF THE SUGAR-BEET SEED INDUSTRY IN THE UNITED STATES. U. S. Dept. Agr. Yearbook 1916 : 399–410, illus. 1917.

[4] TRACY, W. W., Jr. SUGAR-BEET SEED GROWING IN THE ROCKY MOUNTAIN STATES. U. S. Dept. Agr., Farmers' Bull. 1152, 21 p., illus. 1920.

[5] OVERPECK, J. C. SEED PRODUCTION FROM SUGAR BEETS OVERWINTERED IN THE FIELD. U. S. Dept. Agr. Circ. 20, 8 p., illus. 1928.

These results equal the normal seed yield for beets grown under ordinary conditions for seed production elsewhere. In these tests the beets were planted at approximately 2-week intervals, beginning September 1. The beets were planted in the usual manner in 22-inch rows and were spaced either 12 or 24 inches apart in the row. The results gave strong indications that the closer spacings were more desirable.

The test plantings in 1926–27 consisted of plots planted at various dates commencing September 1 and extending to November 1. It was found that September plantings produced almost double the yield of later plantings. In a set of tests planted September 15, 30 plots which were planted in 22-inch rows and blocked to 12 inches, but not thinned to a single plant, gave a yield of 1,394±315 pounds per acre. Nine plots, which were similar, but which were thinned to a single plant, gave 1,548±385 pounds per acre—a dif-

FIGURE 1.—Successful overwintering of unthinned sugar beets in a commercial planting for seed production near Las Cruces, N. Mex. (Planted September 1, 1929; photographed March 27, 1930)

ference in yield which was not significant. A contrasting series to these plots was two sets of nine plots each that were seeded with 9 and 18 pounds of seed per acre, respectively. These plots were planted in 22-inch rows, but the beets were left unthinned. In both cases the yield of seed was greater than from the plots where blocking or blocking and thinning had been done. Indeed, the seed production was the greatest from these plots of any in the entire series, namely, 1,711±192 and 1,831±307 pounds.

The tests in 1927 further showed that in the matter of seed production in the Southwest the problem of maintaining seed viability, presumably by proper handling of irrigation water at the time the seed was setting, was of paramount importance.

The conclusions justified by the work in New Mexico indicate that planting must be made early in the fall if the plants are to be successfully overwintered. (Fig. 1.) Also, there is a strong indication that blocking or thinning of the stand is not necessary, and in all probability is undesirable from the standpoint of yield. In this connection it should be pointed out that the New Mexico area pre-

sents the paradoxical condition of successful sugar-beet seed production in an area where all attempts to raise sugar beets as a commercial crop have failed because of curly-top disease.[6]

It is the purpose of this circular to give additional information which has been obtained by two more years of tests in seed growing in New Mexico, together with some brief, pertinent recommendations for seed growing under southwestern conditions.

EXPERIMENTS OF 1927–28

In the fall of 1927 experimental work was undertaken to determine the effects of different rates of seeding, row widths, and spacing in the row on sugar-beet seed production.

The plots were located in a level field having fairly uniform soil and drainage. The various rates, row widths, and spacing used are shown in Table 1. This series was repeated three times, the same order being maintained. The results are given as averages of three plots in each case, computed in terms of clean seed per acre.

TABLE 1.—*Effect of different rates of seeding, various widths of rows, and spacings within the row on yields of beet seed at State College, N. Mex., 1927–28*

[Planted September 15, 1927. Results represent an average of three plots]

Rate of seeding	Type of planter used	Width of rows	Spacing within row	Individual plot area	Average yield of clean seed per acre
Pounds		*Inches*		*Acre*	*Pounds*
9	Cotton planter	40	Unthinned	0.0392	404
18	Beet drill	22	24 inches [1]	.0215	549
18	do	22	12 inches [1]	.0215	912
9	do	22	Unthinned	.0215	1,412
18	do	22	do	.0215	2,025
60	Grain drill	7	do	[2].0343	2,186

[1] A single plant left in a place.

[2] 1 plot of this planting contained 0.0335 acre.

To plant certain of the plots, the ordinary beet drill set for 22-inch rows was used at two rates of planting, namely, 9 and 18 pounds per acre. The heavier rate of planting was the better. In some cases the plots planted with the beet drill at 18 pounds per acre were left unthinned and other plots were thinned to 12 and 24 inches, respectively. As will be seen from Table 1, the unthinned plots were greatly superior in yield to either of the thinned plots. In another series 40-inch rows were used, seeding at the rate of 9 pounds of seed per acre and leaving the beets unthinned. For these plots an ordinary cotton planter was employed. These beets gave the lowest yield per acre. In sharp contrast to this wide-row planting, an ordinary grain drill was used to plant plots with 7-inch rows, using approximately 60 pounds of seed per acre. The beets in these plots were left unthinned. With the last-named planting no cultivation of any

[6] In the publication previously mentioned (footnote 5) it was reported that the curly-top disease was largely if not entirely avoided by the later summer and fall plantings, but the subsequent experience at the New Mexico station has shown that the curly-top disease may in certain years be present in as high a proportion as 20 to 60 per cent of the plants. The good results obtained in the plots where no thinning of the seedlings was attempted may be related to the curly-top factor.

kind was given. Table 1 shows that the heaviest yield of clean seed, 2,186 pounds per acre, was obtained by this method.

It may be safely concluded from the results of these tests, and in harmony with results previously reported, that close spacing of the rows and close stand in the row are conducive to the most economical use of the soil space, as is shown by the clear trend in seed yields reported in Table 1.

EXPERIMENTS OF 1928–29

In the late summer and fall of 1928 a series of plots was planted to determine the effect of (1) time of planting, (2) rate of seeding, and (3) width of rows upon seed production. In addition, plots were set aside in which the influence upon seed viability of different applications of irrigation water during the blooming period could be ascertained. All the plots were laid out in a long narrow field. The order of the plots can be seen from Tables 2, 3, and 4, in which the original plot numbers are listed. The system of replications used was as follows: A series of plots was planted according to schedule, with an allowance of land for later plantings, each series occurring either two or three times.

The field used, as evidenced by the data, showed three distinct areas in fertility—high, medium, and low—and these areas practically coincided with the series used in these experiments. The plot size is given in each case, this representing an accurate measurement of the area harvested. From these measurements the yields given have been computed on an acre basis in terms of clean seed. To obtain the germination percentage, two samples for each plot were tested, and the results as presented are averages of the plots receiving the same treatment. The figure given represents the average number of seed balls per hundred germinating in sand. Methods of sampling, etc., followed closely the methods outlined for the Magdeburg test.[7]

The plots were harvested July 1 and 2, 1929, and the seed lots for each plot were threshed in two or three weeks. After careful cleaning of seed on the draper, the yield was weighed to the tenth of a pound.

TIME OF PLANTING

These plots were designed to test again the time-of-planting effect upon seed yield. In this set of tests 18 pounds of seed per acre were used throughout, the rows were 22 inches wide, and the plants were left unthinned. Plantings were made on the date given, and in no case was irrigation delayed more than a day after planting. The results showed (Table 2), as in former years, that August 15 to September 15 is the preferable period to plant. The average yields from plantings made on these two dates were 2,958 and 2,748 pounds of seed per acre, respectively, with 3,075 pounds for September 1. (Fig. 2.) It was observed that in the plantings made August 15 and September 1 a considerable percentage of beets became infected with curly top in the fall and early winter months. Sweepings made in the field during this period showed that a few beet leaf

[7] The Magdeburg test is a standard method of testing sugar-beet seed by the sugar-beet trade.

hoppers (*Eutettix tenellus* Baker) were present. These evidently were left overs from the summer broods. In the spring the number of leaf hoppers increased greatly. In spite of this leaf-hopper injury, which was most marked with the early plantings mentioned, little appreciable effect on seed production was noticed, probably because the size of the plants and the heavy stand compensated for the leaf-hopper effects.

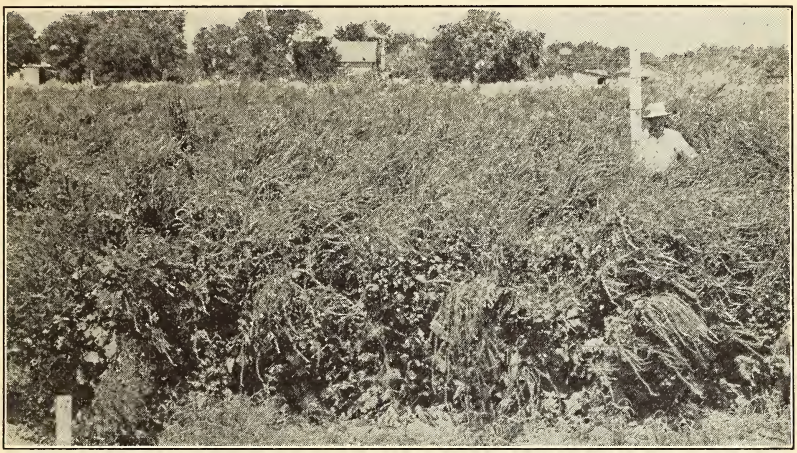

FIGURE 2.—Sugar-beet seed production in an experimental plot. (Planted September 1, 1928; photographed June 21, 1929)

TABLE 2.—*Effect of date of planting on seed yield and viability in 1928–29*

[Planted 18 pounds of seed per acre, in 22-inch rows, left unthinned. All plots irrigated weekly beginning May 14 until harvest (July 1 and 2)]

Plot Nos.	Date of planting	Area of plots		Computed yield per acre			Average germination	Average yield of viable seed per acre
		Series 1	Series 2	Series 1	Series 2	Average		
		Acre	*Acre*	*Pounds*	*Pounds*	*Pounds*	*Per cent*	*Pounds*
10, 14	Aug. 15	0.0535	0.0535	3,486	2,430	2,958	[1] 79.0±1.16	2,337
7, 12	Sept. 1	.0535	.0535	3,047	3,103	3,075	80.0±1.19	2,460
8, 13	Sept. 15	.0535	.0535	3,533	1,963	2,748	80.0± .54	2,198
11, 15	Oct. 1	.0535	.0535	2,299	1,907	2,103	74.0±2.75	1,556
9	Oct. 20	.0535		93		93	67.0±1.90	62

[1] Probable error determined by Bessel's formula, $PE=0.6745\sqrt{\frac{\Sigma d^2}{n(n-1)}}$.

The planting made October 1 gave fair results, but, as will be seen from Table 2, the average yield, 2,103 pounds of clean seed per acre, was much less than the yield from the earlier planting. The planting of October 20 failed almost entirely, the yield being only 93 pounds per acre. This was due to the inability of the immature beets to withstand the winter temperatures. (Fig. 3.)

From this record, which coincides with previous experience, it can be seen that October 1 is about the latest date that beets may be planted with any assurance of a fair crop of seed, and that an earlier date is to be preferred. So far, the leaf-hopper effect, which

has been more severe in the August and early September plantings, has not influenced the seed production in cases where thinning was not practiced.

Another phase of the time-of-planting problem was noted for the first time this season. The germination of the seed from the August and September plantings averaged from 5 to 6 per cent higher than that obtained from seed from the October 1 planting, and 12 to 13 per cent higher than that obtained from the October 20 planting. The significance of this difference in seed quality is brought out forcibly in Table 2, in which it will be seen, for example, that an average of 2,460 pounds of viable seed was produced per acre from the

FIGURE 3.—Failure of seed crop resulting from late planting. (Planted October 20, 1928; photographed June 21, 1929)

September 1 planting, as against 1,556 pounds from the October 1 planting.

The germination figures reported from the other plots are in large part confirmatory, with the possible exception of the 22-pound and 44-pound seedings reported in Table 3 with 14-inch and 7-inch spacings, respectively, which are discussed later. It would be premature to do more than record this finding at this time, since the viability of the seed is doubtless influenced by many factors, such as soil type, soil fertility, spacing of plants, and humidity at time of pollination.

SEEDING RATE, ROW WIDTH, AND PLANT-SPACING EXPERIMENTS

In Table 3 the results with the different plantings under a number of varied conditions are compared.

The experiments of previous years had strongly indicated that better yields were obtained by leaving the seedlings unthinned than were obtained by thinning to a single plant at 12-inch distances. In the 1928–29 experiments this matter was tested again with entirely similar findings. Taking the average figures for the plots, the thinned stand gave 2,153 pounds of seed per acre, while the unthinned stand gave an average yield of 2,953 pounds. In the matter

of costs of seed production, this item is of great importance, for it is obvious that the expensive and slow job of blocking and thinning the beets is thus avoided.

TABLE 3.—*Effect of rate and type of planting on seed yield and viability*

[Planted September 1, 1928; harvested July 1 and 2, 1929]

Plot Nos.	Type of planter used	Width of row	Rate of seeding	Area of plots			Computed yield per acre				Average germination	Average yield of viable seed per acre
				Series 1	Series 2	Series 3	Series 1	Series 2	Series 3	Average		
		Inches	*Acres*	*Acres*	*Acres*	*Acres*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per cent*	*Lbs.*
2, 17, 23	Beet drill	22	[1] 18	0.0267	0.0267	0.0267	3,146	1,910	1,404	2,153	[2] 81.6±0.74	1,757
3, 18, 24	do	22	9	.0267	.0267	.0267	3,446	2,116	1,835	2,466	83.6 ±.93	2,062
4, 19, 25	do	22	18	.0267	.0267	.0267	3,464	2,772	2,622	2,953	84.0 ±.54	2,481
5, 20, 26	Grain drill	14	22	.0213	.0213	.0213	4,319	2,254	1,972	2,848	73.0 ±.91	2,079
6, 21, 27	do	7	44	.0213	.0213	.0213	4,883	3,474	3,286	3,881	73.6 ±.72	2,856

[1] 12 inch spacing, all other plots left unthinned.
[2] Probable error determined by Bessel's formula, $PE=0.6745\sqrt{\frac{\Sigma d^2}{n(n-1)}}$

The question of the quantity of seed to use per acre also received an answer from the tests detailed in Table 3. By comparison of lines 1, 2, and 3 in the table, it will be seen that the seed yield from an unthinned stand obtained from a 9-pound seeding rate per acre was better than that obtained from a thinned stand resulting from an 18-pound seeding rate per acre. On the other hand, the unthinned stand from the 18-pound seeding rate per acre was in most plots so superior to the unthinned stand obtained from the lighter seeding rate (9 pounds) as to indicate definitely that the 18-pound seeding rate is to be recommended.

Taking this type of planting as a standard, this method may be compared with the results obtained by narrowing the rows from 22 to 14 inches and slightly increasing the rate of seeding (i. e., from 18 to 22 pounds). The individual plot yields are somewhat erratic in this case, but it seems likely that the average figures, 2,953 for the standard as against 2,848 for the closer rows and the heavier seeding, show the true situation, that there is no significant difference between the methods as to yield.

In comparing the standard method with the result obtained from drilling 44 pounds of seed in 7-inch rows, it will be seen that the heavier seeding rate per acre gave by far the heaviest seed yields of any in the experiment, an average yield of 3,881 pounds as compared with 2,953 pounds from the standard. This superiority is consistently shown in all the plots and is in harmony with the results of the 1927–28 tests in which the grain-drill sown beets (60 pounds in 7-inch rows) gave the highest yield.

In further analyzing these results, it is desirable to point out that with the narrowing of the rows and increase in crowding of the beets by a higher rate of seeding, there was a drop in the germination percentage of the seed harvested. Further experimentation will be necessary to elucidate this point and to assign the drop in viability to its proper cause; but it seems plausible to assume that in a similar

manner to the late-planted plots already discussed, the condition of overcrowding in the case of the heavy seeding in 7-inch rows brought about an immaturity of the plants which operated against production of seed of good quality.

The possibility that the heavy seeding may have a disadvantage in the matter of seed viability inclines the writers to be conservative in recommending the grain-drill method for seed production and to retain as their standard the 18-pound seeding in 22-inch rows, the stand, however, to be left unthinned.

IRRIGATION PRACTICE DURING BLOOMING PERIOD

The low viability of the seed obtained in 1926–27 caused attention to be focused upon the desirability of testing the effects of different applications of irrigation water upon seed quality. For this purpose six plots were planted at the extreme end of the field in an area where the soil fertility was fairly uniform. Three types of irrigation were employed—weekly intervals, 2-week intervals, and 3-week intervals. The plots were made as large as soil facilities permitted.

The second series of plots was slightly smaller than the first. The irrigation of all the plots and their handling were uniform until May 14, 1929. From that date on plots 28 and 31 were watered every week until June 26. Plots 29 and 32 received water every other week, while plots 30 and 33 received water only three times during this period. The surface soil of the first-named plots was moist throughout the blooming period; in the second set the soil became dry on the surface in the second week; while the third set was suffering for water before the close of the 3-week interval. The fact that the plots lay side by side and were relatively small influenced in part the adjacent plots. The results, however, seem indicative of the true situation. The plot that suffered for water produced the least seed and its viability was 7.5 per cent less than the plot that was irrigated weekly. The plot that was irrigated every two weeks showed 6.5 per cent lower germination than the weekly irrigated plot, but its seed yield was practically the same. The situation in these plots seems adequately portrayed in Table 4, in which the seed yields are expressed in pounds of viable seed per acre.

TABLE 4.—*Effect of irrigation during blooming period on seed yield and viability*

[Planted September 1, 1928, 18 pounds of seed per acre, in 22-inch rows, unthinned, per plot]

Plot Nos.	Irrigation applications[1]	Area of plots		Computed yield per acre			Average germination	Average yield of viable seed per acre
		Series 1	Series 2	Series 1	Series 2	Average		
		Acre	*Acre*	*Pounds*	*Pounds*	*Pounds*	*Per cent*	*Pounds*
28, 31	Weekly	0.0535	0.0400	2,542	2,375	2,458	[2] 80.5±0.69	1,979
29, 32	2-week intervals	.0535	.0400	2,393	2,500	2,446	74.0±1.98	1,810
30, 33	3-week intervals	.0535	.0400	2,084	2,000	2,042	73.0±1.09	1,491

[1] Timed irrigations were started May 14.

[2] Probable error determined by Bessel's formula, $PE=0.6745\sqrt{\frac{\Sigma d^2}{n(n-1)}}$

The findings from this set of plots are in complete harmony with results obtained in the seed-growing practice employed in the western part of the United States. For example, A. W. Skuderna,[8] at Rocky Ford, Colo., has observed that the relative humidity of the air and frequency of irrigation at the time of blooming have a marked effect upon the germination of the seed. His tests at Rocky Ford, covering a period of several years, indicated that the plants required a relatively high humidity to produce seed stock of good viability. Accordingly, frequent irrigations during the blooming period are always given in commercial practice.

FINDINGS FROM EXPERIMENTS

The additional experimental work reported in this circular has given the following findings: First, a planting time between August 15 and September 15 has again proved to be superior in seed yield from the overwintered seedlings in the Rio Grande area of New Mexico. Second, the width of row employed and the rate of seeding are important factors in seed yield. From the results of the 1928–29 season a 22-inch row with an 18-pound rate of seeding would seem to be a safe standard. Closer spacing of rows (7-inch) with a heavier rate of seeding (44 pounds), in which a grain drill was employed, has proved successful experimentally, and this type of planting deserves further test. Third, the viability of sugar-beet seed produced in this area has varied considerably, on account of different conditions, and these conditions need close study. A preliminary test has shown that frequent application of irrigation water during the blooming period may play an important rôle in the production of seed of acceptable viability.

RESULTS OF COMMERCIAL PLANTINGS

As a result of the interest of commercial concerns in the matter of seed production along the lines of the experimental work already reported, several large-scale plantings have been made near Las Cruces, N. Mex. The commercial concerns and the farmers engaged in the enterprise have cooperated closely with the workers engaged in the investigational work and have kindly placed the results of their tests at the disposal of the writers.

In 1927-28 approximately 8 acres were planted for beet-seed production in late September. Of these plantings 7 acres were blocked and thinned to a single plant. Owing to soil conditions and severe curly-top attack, the stand was not uniform. The seed was not harvested from the bulk of this planting of 7 acres, but a portion which was conserved produced a yield of 700 to 800 pounds per acre. On the smaller plot, consisting of 1 acre, a good stand was obtained in the entire planting. The rows were 22 inches wide and were not thinned. The beets showed more than 25 per cent curly-top disease, but apparently the heavy stand nullified any effect from this disease. The seed yield from this plot was 3,452 pounds. (Fig. 4.) The comparison of this figure, from a commercial test, with the computed yields obtained in the smaller replicated plots of the same type of planting is reassuring as to the dependence to be placed upon the

[8] Oral communication.

experimental figures. In comparing the two fields used in these commercial plantings, it should be stated that the 1 acre consisted of very fertile ground which was well watered, thus assuring good growth of the beets before winter. In the 7-acre field the soil was less fertile, the plants were spaced, and the field had such an uneven stand in the spring that the greater part of it was abandoned.

In 1928–29 farmers contracted with a sugar company for seed increase of material furnished by the company. One and one-half acres were grown and 3,105 pounds of seed obtained. The beets were grown in 22-inch rows and left unthinned. Curly top was again prevalent in the seedlings, but since the stand was heavy, this epidemic produced little apparent reduction in the final yields. Another farmer with 2 acres and under the same type of contract

FIGURE 4.—Commercial sugar-beet seed production in southern New Mexico. This field of 1 acre yielded 3,452 pounds of seed. (Planted about September 25, 1927; photographed June 20, 1928)

with the sugar-beet company produced 2,100 pounds of clean seed. The ground in this case was not so fertile, and the planting was late, being made about October 12, 1928. Here again the seed yields check closely with those obtained in the agronomic experiments.

SUGAR-BEET SEED GROWING FROM PLANTS OVERWINTERED IN THE FIELD UNDER MILD WINTER CONDITIONS

With this experimental and practical experience as a background, the following tentative suggestions are made as to seed-growing methods where beets are overwintered in the field. The whole procedure is still in the experimental stage, and the statements made represent the present information on the subject.

SOIL TYPE AND SEED-BED PREPARATION

The land selected for growing sugar-beet seed should be in a high state of fertility. This appears to be one of the essential requirements, since plants must attain considerable size to withstand winter

conditions. As much care and attention should be given to the matter of seed-bed preparation as for any truck crop. Unless the field is of such type and so prepared as to produce a profitable yield of a truck crop, such as cabbage, it is doubtful if it can safely be used for sugar-beet seed production. Applications of manure are necessary, since it has been fairly conclusively shown in the experimental plots and commercial plantings that the highest yields of seed are obtained from land that has been manured and has an abundance of available fertility. The heavier soils have been found to be better adapted than sandy soils. A loam or clay-loam soil, or any fairly heavy soil, provided it does not tend strongly to the heavy adobe type, has so far given good results in sugar-beet seed growing. Sandy soils should ordinarily be avoided, if present observations are at all indicative of soil type in relation to yields produced.

The land should be plowed in July or early August immediately following the application of manure, which should be at the rate of at least 10 tons to the acre. In plowing, good depth is desirable, that is, 6 to 8 inches or deeper. This is necessary because the beet root, even when small, penetrates deeply. The practice in the Rio Grande Valley of New Mexico has been to prepare the ground after the harvest of a small-grain crop in the early summer. In cases where alfalfa fields are plowed up for beet-seed production, the heavy application of the manure may not be so essential if the alfalfa sod is not more than 2 or 3 years old. Old alfalfa fields are sometimes disappointingly low in nitrogenous material. After plowing, great care should be taken in seed-bed preparation. This is best accomplished by using the disk and spike-toothed harrow and following with the ordinary land drag. Large clods must be entirely eliminated. A good seed bed is one in which the soil has been completely turned and so worked at the proper time that the soil is settled, free from air pockets, clods, and unevenness. On a properly prepared soil the shallow-sown seed is placed at uniform depth, so that upon irrigation the seedlings can emerge without obstruction. It is very essential that fields be properly leveled.

Where the border method of irrigation is used the borders may be put in, 30 to 40 feet apart, before planting (fig. 5), or they may be thrown up after planting, the latter method being advised.

PLANTING THE CROP

The experimental work has indicated that the most desirable time to plant is in the latter part of August or early September, although fair results may be obtained from plantings made from September 15 to October 1. Planting the latter half of August or early September is strongly recommended. Late October or November and December plantings have never been successful, because of the killing of the seedlings by freezing during the winter. The beets make very little growth in the fall when planted late, and many are unable to survive the cold weather. It has been noted that many of the late plantings have not produced a very high percentage of seed stalks. As shown in the experiments (Tables 1 and 3), the results obtained in 1927–28 and 1928–29 indicate that drilling in close rows (7 inches) with an ordinary grain drill will give the heaviest yield of seed. Such a procedure requires more seed per acre. The experi-

mental work thus far with various widths of rows and spacings in the row suggests possibilities from heavier rates of seeding and closer spacing of rows. It is doubtful, however, whether sufficient data are yet available to permit recommendation of the grain drill with its heavy seeding as the proper implement for planting the crop. All that can be said is that present evidence indicates that rows fairly close together and with seedlings left unthinned are to be advised for the conditions of the area under consideration.

Satisfactory results so far have been obtained from fields planted with the ordinary beet planter at the rate of 18 to 21 pounds to the acre in 22-inch rows, with no thinning, and this standard practice is certainly to be recommended in preference to any other employing wider rows, less seed, or thinning.

FIGURE 5.—A seed bed in process of preparation

Whether the grain drill or the beet drill is used in planting, the seeding depth should be set for from one-half to 1 inch in a field where the surface soil is the fine mulch described under seed-bed preparation. In a field that has small clods present the planter should be set so that the seeds are just covered. This is necessary, as otherwise when irrigation water is applied and the clods melt down the seed will be buried too deeply.

CULTURAL PRACTICES

Under conditions in the Southwest, it is always necessary to "irrigate the seed up." There is not sufficient moisture in the top 2 inches of soil to bring about the even germination of the seed without an irrigation being supplied. Hence, the border method of irrigation is commonly used. After the crop has been planted and the borders thrown up, the water should be applied. The application of water must be thorough, otherwise the dry areas will show a ragged stand. On heavier soil sometimes two light irrigations are necessary to bring the stand up. Close watch should be kept so that the top 2 inches of soil are not allowed to dry out completely.

After the seedlings emerge, only a few cultivations are necessary, as in the fall months there is comparatively little weed growth. One

cultivation following each fall irrigation with a cultivator equipped with bull tongues or duck feet is all that is usually necessary. It seems probable that slight hilling of the plants in the rows by the use of a shovel type of cultivator tool on each side of the row would be advantageous in protecting the plants during the winter. The following spring the beets are probably the earliest crop to start growth and very quickly shade the ground. One or two cultivations in the spring are all that are usually required. When the grain-drill method of planting is used no cultivation can be given. Weeds thus far have not been a serious problem in the production of sugar-beet seed in the Southwest by the method under discussion, due to the shading of the ground very early in the spring. It is evident, however, that the ordinary precautions for weed control should be followed as necessary.

IRRIGATION

Up to the time of blooming the irrigation water should be applied often enough to keep the beets growing thriftily. The general appearance of the beets and the condition of the soil furnish the criteria governing the frequency of application of irrigations. Experience must determine for each type of soil, local weather conditions being taken into consideration, the proper time of applying water to the crop. In general, it may be stated that the crop must not be allowed to show any excessive wilting or burning, as the seed crop will suffer. The present practice for the conditions found in the area around Las Cruces, N. Mex., are that irrigations are necessary at least once every two or three weeks during the late spring and early summer.

When the plants begin to bloom, frequent applications of irrigation water are very necessary. In the 1927 tests it was found that while a good set of seed was obtained, some of the seed was very low in germination. It is believed that this low germination was due primarily to the failure to supply sufficient irrigation water during the blooming period. It is certain that some of the fields that year became too dry, and besides the effects of this wilting, which possibly injured the plants to a small extent, the proper humidity was not maintained during the pollination period. In commercial practice in the West it is known that the production of viable seed is greatly dependent upon proper timing of the irrigations during the pollination period. Experiments conducted since 1927 seem to indicate that as soon as the plants begin to bloom the field should be irrigated at least weekly. From this it is evident that seed growing will very likely be limited to those areas where abundance of irrigation water makes possible the maintenance of the proper air humidity at this critical period. The exact humidity range most favorable for pollination in sugar beets is not known. Present information seems to warrant the recommendation to keep the ground moist all through this period by weekly irrigations.

HARVESTING THE CROP

Under southwestern conditions the cutting of the seed stalks is one of the most important steps in seed production. Considerable experience is necessary in determining when the growing crop has reached the proper maturity for harvest. The best criterion of

maturity is obtained by examination of the seed balls. These should have reached the hard-dough stage. At this time the foliage is still green, and the seed has not become dry enough to shatter. Upon cutting open a seed ball in the hard-dough stage it will be found that the seed coat is of a very light-brown color and the seed contents are soft but of fairly firm consistency. In determining this period the entire spike (seed branch) must be taken into consideration; the older seeds at the base will just be turning brown, while the greater part of the seed balls on the central portion of the spike will be in the dough stage, and at the tip of the stem there will often be a few immature flowers. The harvesting must be done quickly, because a few days' delay may mean much loss of seed by shattering. The crop is usually ripe and ready for harvest about July 1.

One of two methods may be employed in cutting the beet-seed stalks. They may be cut by hand sickles close to the ground and

FIGURE 6.—Cutting sugar-beet seed stalks with a tractor-drawn mower in southern New Mexico. The seed stalks are picked up and shocked immediately after cutting. (Photographed July 1, 1929)

immediately shocked in bundles from 4 to 5 feet through at the top. However, where the beets are grown without spacing or thinning, as here recommended, considerable difficulty is encountered in hand harvesting because the plants are found to be so closely interwoven in their growth that much shattering of the seed occurs with this type of harvest. In 1929 a mowing machine was used very successfully in cutting the crop. Either a tractor-driven or a 2-horse mower was found to work very successfully. The plants must be picked up immediately after cutting and shocked, as even a delay of half an hour makes the task very difficult. (Fig. 6.) The making of good shocks is ordinarily rather difficult, especially the setting up of the first few bunches. In the 1929 harvest a homemade tripod greatly facilitated this task. (Fig. 7.) This consisted of a 2 by 4, 10 feet long, supported by two legs at one end, thus leaving the 2 by 4 in a slanting position. A hole was bored horizontally in the 4-inch face of the 2 by 4, so that when the frame is set up the hole is 2½ to 3 feet above the ground. Then a short (3-foot) rod, such as an old fork or broom handle, is inserted in the hole.

It is then easy to place four bunches of seed stalks against the support and thus start the shock. After it is started the piece of wood is withdrawn from the hole and the frame can be lifted from the shock.

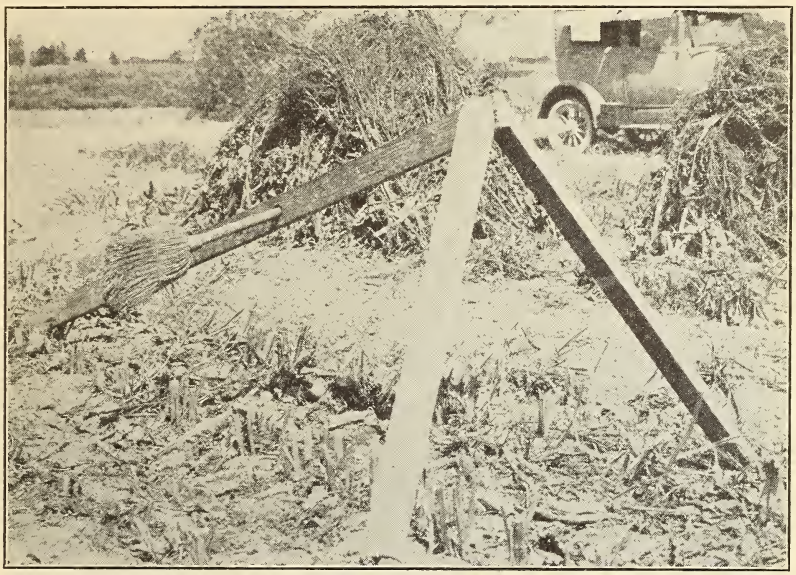

FIGURE 7.—Device used in setting up cut seed stalks

FIGURE 8.—General view of the experimental plots of sugar-beet in shock. (Photographed July 9, 1929)

It is believed that the reaper offers possibilities as a means of harvesting the crop, since it is used successfully for various other seed crops, such as flax, buckwheat, and soybeans; but no trial has yet been given of the reaper with the sugar-beet seed crop. The ordinary binder is not adapted for such use.

No difficulty has been experienced in getting the seed to cure properly. (Fig. 8.) The light summer rains experienced in the Southwest have in no way damaged the seed.

THRESHING

The seed must be thoroughly dry before threshing is done. Under New Mexico conditions the stalks are ready for threshing about one to two weeks after cutting. Previous to 1929 the work was done with a small thresher, such as is used in experiments. In 1929, however, an ordinary commercial thresher (size 28 by 46 inches) was successfully employed. (Fig. 9.) From 5 to 6 tons of seed was threshed in one day. If the ordinary threshing equipment such as is used for grains is employed, the feed carriers must be extended farther than with grain threshing, and lip sieves are preferred to the customary grain sieve. The wind blast also must be considerably reduced, owing to the lightness of the seed. In a properly adjusted thresher the threshed seed should not contain more than 20 to 30 per cent trash. It is impossible to get completely cleaned seed by the threshing operation because of the size and comparatively light weight of the seed balls. Close watch should be kept to see

FIGURE 9.—Threshing sugar-beet seed with a grain thresher, also showing the type of sled used for bringing in the shocks

that seed is not blown out with the trash. The various necessary adjustments that must be made to perform this type of threshing and separating can readily be made by a careful operator. The plants should be fed into the hopper with the seed end first, as this practice also has a tendency to give cleaner seed.

In hauling the shocks from the field to the thresher, team-drawn sleds about 10 by 16 feet, either covered with a canvas or fitted with a box having a tight floor and 6-inch sides, have been found advantageous. (Fig. 9.) Two men working with such a sled can easily topple the shocks on to the sleds, and the loss of seed by shattering is kept at a minimum. Wagons or hayracks may also be used, the beds being covered with canvas. Three men are necessary, however, as the entire shocks must be thrown on the wagon at one pitch to prevent shattering.

CLEANING THE SEED

It is necessary to clean the seed after threshing, because of the presence of leaves, immature seed, and broken pieces of stem. This process requires specially constructed machinery, which can be either made or purchased at reasonable prices. The cleaning process rec-

ommended is first to run the uncleaned seed through an ordinary grain cleaner or fanning mill, to remove as much of the coarse chaff and sticks as possible. It is then necessary to run the seed over a special machine, called a draper, to complete the cleaning. The draper (fig. 10) consists of an endless canvas apron revolving over large rollers. The canvas is made adjustable as to both tension and angle of pitch, and the canvas is lightly shaken by an agitator which causes the seed to roll off the canvas; but sticks and trash, which will not roll, remain on the canvas and are thrown off the end as the canvas apron moves around on the rollers. The uncleaned seed is dumped into the hopper, in which an agitator feed arrangement distributes it over the canvas. The power is applied to a pulley

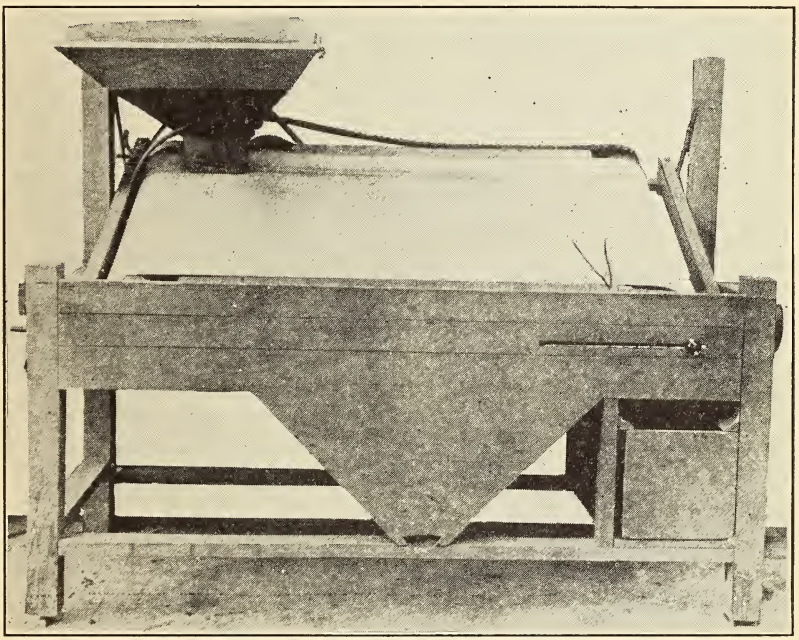

FIGURE 10.—A sugar-beet seed draper

which drives a bevel gear at the lower side of the incline. This arrangement makes it possible to adjust the incline without affecting the position of the drive pulley. A 1-horsepower motor will run the draper. The speed of the drive pulley should not be more than 100 to 110 revolutions per minute. A number of commercial concerns supply this type of draper at prices ranging from about $100 to $200, depending upon the capacity of the machine. A draper having a capacity of at least 2,000 pounds a day, with one or two men operating it, is able to clean a crop from 5 to 10 acres fairly quickly. The seed should be sacked in special 100-pound capacity beet-seed sacks.

GROWING THE CROP ON A COMMERCIAL BASIS

It is believed that as a result of the experimental work that has been carried on, many of the serious obstacles in the production of

a good crop of sugar-beet seed by this method of fall planting and overwintering in the field have now been overcome. The curly-top disease, while apparently not serious so far as the seed crop is concerned, does destroy or injure a rather high percentage of the young plants. It is believed that this damage to the crop has been compensated mainly by thick plantings; and although a large number of beets may be destroyed or injured, a sufficient number of plants will still remain to produce a heavy yield.

Satisfactory seed production seems greatly influenced by the time of planting. The safe time for seeding seems limited to the period from August 15 to October 1, and unless the planting is done early enough to insure fair-sized plants before winter, the risk of a low yield is very great. Furthermore, as has been previously pointed out, considerable care is necessary in selecting the soil suitable for the crop. Unless the grower has available a supply of barnyard manure or unless the soil is naturally in a high state of fertility, experience has shown that the crop should not be attempted. Light-textured soils should be avoided.

From the results here reported, it is evident that seed growing on a commercial scale is practicable in this and other areas presenting similar possibilities for overwintering seedlings in the field.

It is evident that the labor costs are reduced to a minimum and the crop production is more nearly comparable to grain production than to an intensive seed-production practice. Land is used at such a period and the crop is harvested at such a time as to make possible utilization of the land for many other types of crops for the succeeding year. The commercial production of sugar-beet seed in this area has not been extensive enough to permit generalizations as to the expense involved, but from the practices outlined it is clear that aside from land rent, expense for machinery, and similar items the costs involved in this crop are those connected with land preparation, including manuring, planting, irrigation, cost of seed, weed control, and seed harvesting and cleaning. It can reasonably be expected that the advantages of the methods of seed production here described, which are typically machine methods as contrasted with hand-labor methods, are going to make possible seed production at much less expense than would be possible in other areas in the United States, where a great deal of hand labor would be involved with the seed crop.

The development of the sugar-beet seed industry in suitable areas in the United States should take an orderly course as farmers become acquainted with the methods involved and as sugar-beet factories find it to their advantage to increase their own stocks of sugar-beet seed. This leads logically to a very necessary word of warning to growers.

Before planting for seed production, it is necessary that a contract be made for the disposal of the crop. No grower can expect to plant commercial seed, produce a crop, and dispose of the seed as he would a crop of wheat or corn or some other farm commodity. The sugar companies seek very carefully to insure the quality of their seed supply, because the losses ensuing from low-quality seed would cause serious economic consequences. The present practice is for the interested sugar-beet company to make arrangements with the seed

grower to increase a seed stock furnished. The company contracts to purchase the seed increase at a fixed sum per pound subject to certain standards of cleanness and definite viability standards (70 per cent and upward), depending on the size of the seed ball. Any grower would be unwise to grow sugar-beet seed until some such arrangement for purchase of the crop has been made.

It is essential that sugar beets, red beets, or mangel-wurzels shall not be permitted to go to seed in the vicinity of beet fields grown for seed purposes. A potential danger is the possibility of beets escaping cultivation and growing as volunteers or even as weeds along fences, roadsides, or ditch banks. This has happened in parts of southern California. So far, in the vicinity of Las Cruces, N. Mex., there has been no apparent difficulty in this respect; but if such a condition should arise, the district would likely be abandoned as a commercial seed-producing area, since these volunteer beets would readily cross with the growing crop and very seriously injure the quality of the sugar-beet seed. The same is true of growing beet seed in close proximity to red beets, mangel-wurzels (stock beets), or chard growing for seed purposes. These crops cross-pollinate with sugar beets very easily, so that sufficient distance (at least one-half mile) should separate the nearest sugar-beet seed field from the above-mentioned crops when they are being grown for seed or are allowed to bloom.

All growers of sugar-beet seed have a responsibility in this regard. The field in which the crop has been grown contains shattered seed. The field should be promptly irrigated, and after the seed has germinated the young plants should be destroyed by clean cultivation.

SUMMARY

For the obvious advantages to be derived from the development of an American sugar-beet seed industry, attention is again called to seed-production experiments in areas where, by taking advantage of mild winter conditions, sugar-beet seedlings from seed planted in the fall were successfully overwintered in the field and brought to seed production the succeeding year.

For such a procedure the experiments reported show the desirability of late summer and early fall plantings. Unthinned stands of sugar beets, in 22-inch rows, obtained by a seeding rate of 18 pounds per acre seem from present evidence safe and to be recommended. Close spacing between rows with a heavy seeding (44 to 60 pounds) with no thinning of the stand has given high yields. However, further experimental work should be done before this method can be definitely recommended.

The problem of securing seed of satisfactory viability has been at least partly met by the proper timing of irrigations during the blooming season. In commercial plantings, results in seed yields here approximated the experimental results, and where proper attention to soil and handling has been given the results have been promising in the returns obtained.

Recommended practices for soil selection, field preparation, cultivation, irrigation, harvesting, and seed cleaning in sugar-beet seed production in the Rio Grande Valley of southern New Mexico are given.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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